ORIGINAL ARTICLE

Validation of a field test to determine the maximal aerobic power in triathletes and endurance cyclists

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Objective: To validate a field test to assess the maximal and submaximal exercise aerobic adaptation under specific conditions, for endurance modality cyclists and triathletes.

Methods: 30 male and 4 female endurance modality cyclists and triathletes, with heterogeneous performance levels, performed three incremental tests: one in the laboratory and two in the field. Assessment of the validity of the field protocol was carried out by the Student's *t* test, intraclass correlation coefficient (ICC) and coefficient of variation (CV) of the maximal variables (maximal aerobic speed (MAS), maximal aerobic power (MAP), maximal heart rate (HR_{max}), maximal blood lactate concentration ([La⁻]_{max}) and maximal oxygen uptake (VO_{2max})) and submaximal variables (heart rate, HR) measured in each one of the tests. The errors in measurement were calculated. The repeatability of the field tests was assessed by means of the test-retest of the two field tests, and the validity by means of the test-retest of the laboratory test with respect to the mean of the two field tests.

Results: No significant differences were found between the two field tests for any of the variables studied, but differences did exist for some variables between the laboratory tests with respect to the field tests (MAP, [La⁻]_{max}, humidity (H), barometric pressure (Pb) and some characteristics of the protocols). The ICC of all the variables was high and the CV for the MAP was small. Furthermore, the measurement errors were small and therefore, assumable.

Conclusions: The incremental protocol of the proposed field test turned out to be valid to assess the maximal and submaximal aerobic adaptation.

The monitoring of different physiological variables (heart rate (HR), blood lactate concentration (La⁻) and oxygen uptake (VO₂)) and mechanical variables (speed (S) and mechanical power output (P)) has been performed for decades to assess the adaptation to exercise in cyclists and, more recently, in triathletes. These types of test used to be conducted in the laboratory in order to have greater control over the measurement conditions. Thanks to technological developments, many of these variables can now be validly and reliably measured in training and competition situations.¹ Functional field evaluation opens up new perspectives. It is also a useful tool to assess the specific adaptation of athletes, overcoming the problems posed by the functional laboratory evaluation on cycloergometer.²

Specificity plays a very important part in the functional evaluation of athletes. In this sense, different authors have tried to reproduce the specificity of cyclists with their actual bicycle in different manners: on treadmills,³ in a wind tunnel^{4–6} on rollers,^{7–8} in velodromes,^{9–15} on the road^{16–19} and even in towns.¹⁵ The majority of the existing studies on cycling-specific tests deal with the relationship between the displacement speed and the energy expenditure^{12–15–17–19–20} or the mechanical power output,^{14–16–18} and there are only a few authors who have validated specific protocols. Some have proposed triangular protocols in the velodrome to determine the anaerobic threshold by means of the heart method,¹¹ to estimate the maximal oxygen uptake (VO_{2max}),¹⁰ or to assess the functional maximal aerobic power (MAP);¹⁵ others have reported rectangular protocols to assess the economy.^{12–13}

The only studies available in the literature that validate a field protocol to measure maximal and submaximal variables with respect to a reference test in laboratory are those proposed by Leger *et al.*⁹ and Padilla *et al.*¹³ The first has a triangular

nature, is non-invasive and economical to apply, but it presents a series of important biases and methodological errors to be considered. The second has a rectangular nature and is invasive, as samples of lactate in blood have to be taken. In this case, the MAP of the athlete must also be previously known to determine the protocol. Therefore, no validated field test has been found in the literature with a system that validly measures the mechanical power output, with a standardised protocol for a broad population, and which is specific, of a triangular nature, non-invasive and easy and economical to apply. The objective of this study was to validate a field test to assess the maximal and submaximal aerobic adaptation to exercise under specific conditions, for endurance modality cyclists and triathletes.

METHODS

Subjects

Thirty male and four female national-level and international-level mountain bikers (n = 4), road cyclists (n = 11) and triathletes (n = 19) participated in this study, satisfying the following inclusion criteria: having >2 years' competitive experience, being active, not having any illness or injury and having a VO_{2max} of over 50 ml/kg/min. Values of subjects' mean (SD) age, height and weight were the following: 24 (5) years, 176.3 (6.6) cm and 69.4 (7.6) kg. The mean level of competitive experience was 4.5 (1.7) years. All experimental procedures were approved by the Ethics Committee of the High Performance Centre of Sant Cugat, Barcelona, Spain, all subjects gave written informed consent prior to testing.

Abbreviations: ICC, intraclass correlation coefficient; MAP, maximal aerobic power; MAS, maximal aerobic speed

Table 1 Comparison of field tests (mean $\pm$ DE)

Test	Retest
P ₀ (%MAP)	51.4 (6.3)
Δ P (W)	11.7 (1.9)
MAP (W)	404 (63)
S ₀ (km/h)	30.6 (1.8)
Δ S (km/h)	0.65 (0.04)
MAS (km/h)	41.5 (1.7)
HR _{max} (beats/min)	185 (11)
[La ⁻] _{max} (mM)	6.9 (1.7)
PC _{max} (rpm)	99 (4)
V _{Wind} (km/h)	1.9 (2.1)
T (min:s)	17:38 (02:07)
T ^a (°C)	20.3 (5.0)
H (%)	62.1 (15.1)
Pb (mm Hg)	728.4 (3.6)

P₀, initial load; Δ P, load increase; MAP, maximal aerobic power; S₀, initial speed; Δ S, speed increase; MAS, maximal aerobic speed measured with the SRM; HR_{max}, maximal heart rate; [La⁻]_{max}, maximal blood lactate concentration; PC_{max}, maximal pedalling cadence; V_{Wind}, mean wind velocity; T, total duration; T^a, temperature; H, relative humidity; Pb, barometric pressure.

Experimental design

The experimental protocol consisted of performing three tests. The first was performed on a cycloergometer with electromagnetic brake (CardiGir, G&G Innovación, La Bastida, Alava, Spain) and acted as gold standard. During the same week, two sessions were carried out to familiarise participants with the track cycle (traditional aluminium track bike with conventional handlebar and wheels with aluminium spokes), the velodrome and the field protocol. Then, the second and third tests were performed in the velodrome with a week's gap between them. They took place in the afternoon to control the effect of biorhythms on performance.²¹ The training and nutritional conditions under which the athletes performed the tests were controlled, programming an active rest during the 48 h prior to each test (1-h cycling at 50% MAP) and a carbohydrate-rich diet (80%) during the 3 days prior to each test.

Incremental laboratory tests

After 10-min warm-up at 100 W, the test began at an initial load of 130 W for the women and 200 W for the men. Then, 30-W load increases were made every 4 min until $R \geq 1$. From then on increases of 10 W/min were made until exhaustion. The VO₂ and the HR were measured in real time, breath by breath, during the whole test, by means of an indirect integrated calorimetry system (Quark PFT, Cosmed, Rome, Italy). The MAP was calculated by means of the equation proposed by Kuipers *et al.*²² The VO_{2max} was determined as the mean value of the VO₂ of the last 30-s effort, when at least two criteria recommended by the British Association

Figure 1 Comparison of the heart rate (HR) at each one of the relative work intensities among field tests. MAP, maximal aerobic power.**Table 2** Standard error of the estimate and 95% CI for the variables that CCI has been calculated for

	SEE (95% CI)
MAP (W)	35.2 (0.906 to 0.977)
MAS (km/h)	1.5 (0.781 to 0.945)
HR _{max} (beats/min)	7 (0.857 to 0.967)
[La ⁻] _{max} (mM)	1.8 (0.564 to 0.896)

HR_{max}, maximal heart rate; [La⁻]_{max}, maximal blood lactate concentration; MAP, maximal aerobic power; MAS, maximal aerobic speed.

of Sport and Exercise Sciences²³ were satisfied. The blood lactate concentration [La⁻] was measured with a portable lactate analyser (Lactate Pro, Arkray, Kyoto, Japan) at the third minute after the end of the effort, being considered this register as the [La⁻]_{max}.²⁴ Blood samples were taken from the ear lobe.

Incremental field test

After 10-min warm-up, the test began with an initial load corresponding to the 50% MAP of the laboratory test. The load increases were 12.5 W/min in order to reach exhaustion in no more than 20 min,²⁵ which was the expected duration of the laboratory test. The displacement speed was estimated by means of the equation of Di Prampero *et al.*¹⁶ and was imposed by means of an acoustic pacemaker with a laptop PC, amplifying it with a sound system placed in the centre of the track. The athletes made the signal coincide with each one of the two persecution lines that divide the wooden velodrome into two 125 m parts. The test ended when the athlete accumulated a 5 m delay with respect to the line.¹⁷ The bicycle tyre pressure was inflated to 133.8 ψ and the environmental variables (temperature (°C), H (%)) and Pb (mm Hg)) were controlled and validated by the Fabra observatory of Barcelona. The wind velocity was measured with an anemometer Speedwatch (JDC Electronic SA, Yverdon-les-Bains, Switzerland), although it was disregarded to calculate MAP and VO_{2max}. The displacement speed and mechanical power output were directly measured by means of an SRM crank dynamometer (Schoberer Rad Meßtechnik, Jülich, Germany).²⁶ The VO_{2max} reached at the end of the test was estimated by means of the equation of Di Prampero *et al.*¹⁶

Statistical analysis

Descriptive statistics were generated for all variables. The following were used to measure the absolute reliability: Student's *t* test, intraclass correlation coefficient (ICC) and coefficient of variation (CV) of the maximal variables (maximal aerobic speed (MAS), MAP, HR_{max}, [La⁻]_{max} and VO_{2max}) and

Figure 2 Repeatability of the field test. MAP, maximal aerobic power.

Table 3 Comparison of the laboratory test with respect to the field tests (mean $\pm$ DE)

	Laboratory test (test)	Field test avg. (retest)
P ₀ (%)	28.6 (3.4)	51.5 (5.4)***
Δ P (W/min)	7.7 (0.8)	11.7 (1.4)***
MAP (W)	354.7 (41.3)	407.8 (61.9)***
HR _{max} (ppm)	185 (11)	184 (12)
[La ⁻] _{max} (mM)	8.4 (2.6)	6.9 (1.6)**
PC _{max} (rpm)	87.7 (10.0)	99.7 (3.9)***
T (min:s)	23:54 (03:27)	17:55 (01:53)***
T ^a (°C)	21.8 (1.9)	20.7 (4.0)
H (%)	59.7 (7.3)	65.0 (13.0)*
Pb (mm Hg)	747.7 (12.0)	728.2 (2.8)***

P₀, initial load; Δ P, load increase; MAP, maximal aerobic power; HR_{max}, maximal heart rate; [La⁻]_{max}, maximal lactatemia; PR_{max}, maximal pedalling rate; T, total duration of test; T^a, temperature; H, relative humidity; Pb, atmospheric pressure; NSD, no significant differences.

*p<0.05; **p<0.01; ***p<0.001.

submaximal variables (HR). The determination of the Pearson correlation coefficient was used to verify the existence of relationships between the different variables studied, taking the relationships into account when $r \geq 0.8$; in addition, the SEE and the 95% CI of the previous correlations were calculated. Significance level was determined at $p < 0.05$ for all statistical tests carried out. The repeatability and validity of the field test was assessed by studying the reliability by means of the test-retest between the two field tests and between the laboratory test and the mean of the two field tests, respectively. The confidence limits of Bland and Altman²⁷ were calculated to assess the measurement errors.

RESULTS

Repeatability of the field test

The results from adapting the study sample to the field tests did not show remarkable differences for any of the maximal variables (MAP, MAS, HR_{max} and [La⁻]_{max}; table 1) and submaximal variables (HR; fig 1) studied.

Some high and significant ICC values were obtained for the repeated measurements of each one of the maximal variables studied: MAP (0.953; $p < 0.001$), HR_{max} (0.931; $p < 0.001$), [La⁻]_{max} (0.787; $p < 0.001$) and MAS (0.890; $p < 0.001$; SEE and 95% CI of ICC are presented in table 2); and a relatively low CV for the MAP (15%). The Bland-Altman plots showed that in the MAP measurement the bias $\pm$ random error was -8.1 ± 52.6 W, with a bias close to zero (-8.1 W or 2%) and great accuracy. Furthermore, 95% of the differences or CI of those measurements was located from 44.5 to -60.7 W, there being an acceptable random error that could be considered to be acceptably small for the type of test assessed (fig 2).

Taking all these results into account, the proposed field protocol was considered to be repeatable.

Validity of the field test

The results from adapting the study sample to the laboratory test with respect to the mean of the two field tests did not show any significant differences for the HR_{max} (table 3) or for the submaximal HR, either, at each one of the relative work intensities (fig 3). Significant differences were found between the protocols for variables P₀, Δ P and t and in some maximal (MAP, [La⁻]_{max} and PC_{max}) and environmental (H and Pb) variables (table 3).

Some high and significant ICC were obtained for the repeated measurements of the maximal variables MAP (0.838; $p < 0.001$), HR_{max} (0.862; $p < 0.001$), but not for the [La⁻]_{max} (0.474; $p < 0.05$; SEE and 95% CI of ICC are presented in table 4). A relatively low CV was found for the MAP (13%).

Figure 3 Comparison of the submaximal heart rate (HR) between the laboratory test and the field tests. MAP, maximal aerobic power.

By contrast, the Bland-Altman plots showed a bias $\pm$ random error of 53.2 (77.1) W, with a small bias (53.2 W or 13.9%) and acceptable accuracy in the MAP measurement. The 95% value of the differences or CI of these measurements ranked from 130.2 to -23.9 W, showing an acceptable random error that can be considered to be acceptably small for the type of test assessed (fig 4). Finally, no significant differences were found between the VO_{2max} measured in laboratory and that estimated in the field tests (61.5 ± 5.9 vs 62.9 ± 9.4 VO_{2max}, respectively).

Taking all these results into account, the proposed field protocol was considered to be valid.

%MAS-%MAP relationship

The %MAS-%MAP relationship was represented by means of the function $\%MAP = 0.0818e^{(2.5167\% \text{ MAS})}$, obtaining a high coefficient of determination ($R^2 = 0.998$) and an acceptable SEE (13.7%; fig 5).

DISCUSSION

By means of typical statistics to assess the absolute reliability in this type of study^{9-13, 15} and of the measurement errors,²⁷ the results indicated a high absolute reliability for the validity study (see Results: validity of the field test section) and especially for the repeatability study (see Results: repeatability of the field test section).

Repeatability of the field test

There was a random error of $\pm 12.9\%$ in the repeatability study, which was not entirely explained by the variability of the SRM system ($\pm 1.8\%$).²⁸ The remaining $\pm 11.1\%$ (± 45 W) was due to other variables²⁹ such as repetition (only two test repetitions were carried out). The bias of 2% was assumed in its entirety to be a result of the accuracy of the SRM system (2.5%).³⁰ Consequently, the errors were small, and the field protocol was considered to be repeatable.

Validity of the field test

There was a random error of $\pm 20.2\%$ in the validity study which was not entirely explained by the variability of the SRM system ($\pm 1.8\%$).²⁸ The remaining $\pm 18.4\%$ (± 75 W) was due

Table 4 Standard error of the estimate (SEE) and 95% CI for the variables that CCI has been calculated for

	SEE	95% CI
MAP (W)	83.7	0.675 to 0.919
HR _{max} (ppm)	9	0.725 to 0.931
[La ⁻] _{max} (mM)	3.7	-0.053 to 0.737

HR_{max}, maximal heart rate; [La⁻]_{max}, maximal blood lactate concentration; MAP, maximal aerobic power.

Figure 4 Validity of the field test. MAP, maximal aerobic power.

to other variables²⁹ such as repetition, differences in the environmental variables (wind effect, differences in H and Pb), and biomechanical differences (cycloergometer vs track bicycle adaptation, curve effect,³¹ and differences in protocols). The bias was 13.9% and was not entirely explained by the bias introduced by the measurement systems (SRM (2.5%)³⁰ and cycloergometer (2–4%)³²). Although the Cardgirus cycloergometer has not been validated in any study, the error guaranteed by its manufacturer is $\pm 2\%$, within the range obtained with other electromagnetic brake cycloergometers.³² The remaining 7.4% (30 W) was due to other variables:²⁹ the same ones that affected the random error plus a measurement error of the SRM system that was not indicated by the manufacturer. The SRM measures the mechanical power output by means of the function:

$$P = T \cdot \omega$$

where T is the torque expressed in N/m ($T = Fd$, being F the force measured by the SRM system (N), and d the length of the crank (m)) and ω is the angular velocity, expressed in rad/s and obtained from the pedalling rate also measured by the SRM system ($\omega = 2\pi (\text{rpm}/60)$).²⁶ In contrast, following the classical physics this calculation would have to be carried out with another equation, which would consider the non-uniform behaviour of the pedalling rate. Assuming a uniform acceleration of the pedalling rate during each differential of time, the instantaneous mechanical power output is calculated by:

$$P = T(\omega_0 + \Delta\omega/2)$$

where ω_0 is the initial pedalling rate and $\Delta\omega$ is the differential of the pedalling rate. The average value of mechanical power output would be obtained by calculating the mean of the instantaneous values. The difference between the SRM and these proposed equations could probably explain part of the random error. However, the measurement errors were small, and the field protocol was considered to be valid.

By contrast, the differences found in the MAP between the laboratory test and the field tests had no influence on the aerobic adaptation and the estimation of the $\text{VO}_{2\text{max}}$, as suggested by other authors.³³

This study assessed the validity of a triangular test in velodrome evaluating the relationship between the aerobic adaptation and the mechanical power output measured directly with the SRM system in endurance cyclists and triathletes. All

Figure 5 Relationship between the %MAS (maximal aerobic speed) and the mean %MAP (maximal aerobic power) of the study subjects.

the tests reported in the literature (see above) are not well standardised^{9 10 12} except for the Padilla *et al*¹³ protocol, which is of a different nature. In the present study, the initial load corresponded to 50% MAP and the load increase was 0.65 km/h/min or 11.7 W/min, similar to those used by Leger *et al*⁹ (1 MET·2 min⁻¹) and Ricci and Leger¹⁰ (1–2 km/h·2 min⁻¹), in spite of the fact that these other protocols are not strictly progressive: that of Leger *et al*⁹ because the progressiveness is biased as suggested by the actual authors and others because they do not carry out homogeneous speed increases.^{10 12} Where all the studies do coincide is in ending the test when exhaustion is reached, which in the present study was when the athlete accumulated a 5-m delay with respect to the reference line.¹⁷

In this study, the performance (MAS) of the sample (41.7 km/h) was greater than in others (39.7 and 39.3 km/h).^{10 12} Furthermore, the same aerobic adaptation was observed between the laboratory test and the field tests for each one of the relative work intensities studied, in agreement with that observed by other authors.^{10 13} On the other hand, $[\text{La}^-]_{\text{max}}$ in this study was greater in the laboratory test than in the field

Table 5 Protocol A standardisation

Steps	S (km/h)	P (W)	VO ₂ (ml/kg/min)
1	22.0	63	15.6
2	22.7	67	16.4
3	23.3	72	17.3
4	24.0	77	18.3
5	24.6	82	19.3
6	25.3	88	20.3
7	25.9	94	21.4
8	26.6	100	22.6
9	27.2	106	23.8
10	27.9	113	25.1
11	28.5	120	26.4
12	29.2	127	27.7
13	29.8	134	29.2
14	30.5	142	30.7
15	31.1	150	32.2
16	31.8	159	33.8
17	32.4	168	35.5
18	33.1	177	37.2
19	33.7	186	39.0
20	34.4	196	40.9

Table 6 Protocol B standardisation

Steps	S (km/h)	P (W)	VO ₂ (ml/kg/min)
1	27.0	104	23.4
2	27.7	111	24.7
3	28.3	117	26.0
4	29.0	125	27.3
5	29.6	132	28.7
6	30.3	140	30.2
7	30.9	148	31.7
8	31.6	156	33.3
9	32.2	165	35.0
10	32.9	174	36.7
11	33.5	183	38.5
12	34.2	193	40.3
13	34.8	203	42.2
14	35.5	213	44.2
15	36.1	224	46.3
16	36.8	235	48.4
17	37.4	247	50.6
18	38.1	259	52.9
19	38.7	271	55.2
20	39.4	284	57.6

tests (6.9 vs 8.4 mM), unlike other authors who did not find any significant differences,¹⁰ and others who found opposing values (higher in the field test than in the laboratory test).¹³ The greater $[La^-]_{max}$ obtained in laboratory could be due to the greater duration of this test with respect to the field test (23:54 vs 17:55 min; $p < 0.001$, respectively), although paradoxically it was reached with a higher pedalling rate in the velodrome than in the laboratory (99.7 vs 87.7 rpm; $p < 0.001$, respectively), so the $[La^-]_{max}$ would have to have been greater in the velodrome due to a greater use of fast-twitch fibres and to the glycolysis activity.³⁴ A possible reason may be that perhaps these athletes have a greater economy of motion on the track, due to the specific nature of the activity.

Standardised protocols

In agreement with the mean data of the field tests, four protocols for both sexes were standardised, depending on the performance level. The estimation of the mechanical power output and VO₂ for each stage of the protocols was carried out by means of the Di Prampero *et al*¹⁶ equation, using the mean morphological variables of the study group ($M = 69.4$ kg, $P_b = 747.7$ mm Hg, $T^a = 295$ K and $ASC = 1.84$ m²). The speed increases were the same for the different protocols (0.65 km/h/min), while the initial speed changed for each one. The proposal was: protocol A for young cyclists and triathletes ($V_o = 22.0$ km/h; table 5), protocol B for junior cyclists and national level triathletes ($V_o = 27.0$ km/h; table 6), protocol C for U23 cyclists and international level triathletes ($V_o = 32.0$ km/h; table 7) and protocol D for professional cyclists and triathletes ($V_o = 37.0$ km/h; table 8). The VO₂ was not estimated for protocol D because the Di Prampero *et al*¹⁶ equation overestimates considerably the VO_{2max} for those speeds.

To calculate the MAS as accurately as possible the following formula was proposed:

$$MAS \text{ (km/h)} = S_f + [(t \cdot d^{-1}) \cdot \Delta S]$$

where S_f is the speed of the last complete stage (km/h), t is the time the last stage was maintained (s), d is the duration of the last stages of the test (60 s in this case) and ΔS is the

Table 7 Protocol C standardisation

Steps	S(km/h)	P (W)	VO ₂ (ml/kg/min)
1	32.0	162	34.5
2	32.7	171	36.2
3	33.3	180	37.9
4	34.0	190	39.7
5	34.6	200	41.6
6	35.3	210	43.6
7	35.9	221	45.6
8	36.6	232	47.7
9	37.2	243	49.9
10	37.9	255	52.2
11	38.5	267	54.5
12	39.2	280	56.9
13	39.8	293	59.4
14	40.5	306	61.9
15	41.1	320	64.6
16	41.8	335	67.3
17	42.4	349	70.1
18	43.1	364	73.0
19	43.7	380	75.9
20	44.4	396	79.0

differential speed between the last stages of the test (0.65 km/h in this case).

%MAS–%MAP relationship

By contrast, the %MAS–%MAP relationship has been proved to be a good tool to estimate the relative work intensity (%MAP) at which an athlete cycles in the velodrome and with controlled atmospheric variables, if the current displacement speed and the MAS are known. In this study, a high correlation coefficient (0.997) and an acceptable SEE (13.7%) for this relationship were found. Marion and Leger¹² found a smaller correlation coefficient (0.981) and SEE (5.7%). This may be due to the different methodology used to calculate the %MAP. In the present study the %MAP was calculated by means of the mechanical power output measured by the SRM, while these other authors estimated the VO₂ in the velodrome by means of retroextrapolation and expressed it as a percentage of the VO_{2max} calculated in the laboratory.¹² Consequently, in spite of the smaller SEE, the methodology used in the present study seems to be more accurate.

Table 8 Protocol D standardisation

Steps	S (km/h)	P (W)
1	37.0	240
2	37.7	251
3	38.3	264
4	39.0	276
5	39.6	289
6	40.3	302
7	40.9	316
8	41.6	330
9	42.2	345
10	42.9	360
11	43.5	375
12	44.2	391
13	44.8	407
14	45.5	424
15	46.1	442
16	46.8	459
17	47.4	478
18	48.1	496
19	48.7	516
20	49.4	535

What is already known on this topic

- Of all the protocols to evaluate the aerobic adaptation on velodrome cyclists referred to in the literature, most have not been properly validated.
- Others have compared the cardiovascular and metabolic response in velodrome with respect to that obtained in the laboratory.
- However, no other reports have been validated by comparing the mechanical power output in the velodrome with respect to that of the laboratory.
- Nowadays, by means of power meters, it is possible to measure the mechanical power output under training-specific and competition-specific conditions.

What this study adds

- This study has validated a triangular protocol to exhaustion in the velodrome to evaluate the aerobic adaptation of cyclists and triathletes by means of the SRM power meter.
- In addition, different kinds of protocols have been proposed depending on the athlete's performance level.

In conclusion, the results of this study indicate that the field test proposed is valid to assess the aerobic exercise adaptation in endurance cyclists and triathletes, under specific conditions. The %MAS–%MAP relationship is a good tool to estimate the %MAP that an athlete develops in the velodrome.

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